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DAVID CLARK COMPANY
INCORPORATED

OCTOBER 1963

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SIX MONTH

PROGRESS REPORT

DEVELOPMENT AND EVALUATION

OF

PRESSURE SEALING CLOSURE (U)

EC11-28-0264

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NATIONAL AERONAUTICS

AND

SPACE ADMINISTRATION

DAVID CLARK COMPANY, INCORPORATED

WORCESTER, MASSACHUSETTS

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DAVID CLARK COMPANY
INCORPORATED

October 15, 1963

SECTION I

DEVELOPMENT OF FULL PRESSURE SEALING CLOSURE

DURING PERIOD OF APRIL 1961 TO MARCH 1963

[redacted]

SECTION I: DEVELOPMENT DURING PERIOD OF APRIL 1961 TO MARCH 1963

NOTE: Section I covers the early stages of progress and development prior to the David Clark Company's commitment to the National Aeronautics and Space Administration's contract, number NAS 9-1186. Financial responsibilities incurred during this period of time in the development of this project, have not been assigned to the afore mentioned contract.

A. DEVELOPMENT MATERIALS

1. Nylon block webbing P-1817 size 1 23/32 x 1/16 inch (Bally) Type XII Mil-W-4088C.
2. Nylon braid S/16171 Type 1A sage green Mil-65040-A (P-428) (Thomas Taylor and Sons).
3. Spring locking seal DWG. M-136-5 and spring flattened DWG. X-4054.
4. Primer for nylon webbing MD-1, ACS-548.
5. Elastomer, neoprene compounds SW 2RT/ACS-523 and ACS-346.
6. Mold-release, Dow Corning #230 fluid.
7. Mold DWG. M-144, M-D-303, M-D-306, and M-D-271.
8. Spring locking shaft (cable) DWG. M-144-2, M-136-3, and D-B399.
9. Gear Box DWG. X-D-415.

B. DEVELOPMENT EQUIPMENT

1. Hydraulic press with 70 ton capacity and 310° F hot plates.
2. Laboratory 1/4 extruder.
3. Laboratory rubber mill 6 x 16.
4. Special template for going assembly.
5. Heating Unit (hot cutting).
6. Hydrostatic tester (Q.C.).
7. Pyrometer range 50° to 400° F.

C. DEVELOPMENT PROGRESS

In April of 1961, a new product concept was revealed which suggested the practicability of a mechanically operated full pressure suit entrance closure. It was anticipated that if this sealing closure assembly could be completely successful, it would provide two highly desirable advantages over the slide fasteners used in spacesuits. These advantages would be such that this sealing closure apparatus would provide a greater gas reliability and would eliminate the present required use of assistance during donning procedures.

The general design of this sealing closure would incorporate a pair of oval shaped helical springs which would be molded into fabric reinforced neoprene installation tapes. A square shaped flexible drive cable, which is threaded along a portion of its length, would engage the closure by collecting the helical springs and apply continuous tension to the pressure sealing surfaces. The drive cable would engage and disengage the helical springs by means of a crank operated gear mechanism, which would be remotely located to the closure.

1. FIRST PROTOTYPE

Due to the limited materials available, the fabrication of molds and the first twelve (12) inch prototype sealing closure progressed slowly. At the time of their completion a sealing closure was constructed, consisting of a high durometer neoprene nylon with an inner structure of reinforcing fabric, helical springs installed between each sealing lip (before the molding operation), and a round helical spring locking shaft to temporarily replace the crank operated gear mechanism which had not been as yet in the process of fabrication.

The spring locking shaft was inserted through the helical springs of the sealing closure for the first evaluation of this new concept. It was concluded during the examination of this prototype closure, that a great deal of research and development would be necessary to complete this item with any degree of success. A few of the problems that were revealed are as follows:

a. In molding this sealing closure a means of controlling the helical spring pitch and rubber flow would be extremely difficult.

b. There would be a problem in obtaining good adhesion of rubber to spring steel (helical springs) and the nylon substraight.

c. The spring locking shaft was very difficult to thread through the helical springs because of excessive friction.

d. Excessive bulk was caused by the spring locking shaft.

e. The design and fabrication of the crank operated gear mechanism would involve a great amount of time for research and development.

f. A special spring locking flexible cable would require extensive research and development.

Due to the other priorities at this time, further development of this item was compromised until July of 1962. At this time, a review was undertaken to determine the designs and components which were more outstanding and could be used for an incoming contract. It was found that this new

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requirement would justify the continuation of the sealing closure, at which time development of this project was geared to full expediency.

2. SECOND PROTOTYPE

To operate this sealing closure a crank operated gear box assembly was designed and fabricated to act as the remote closing device. The design and operation of this gear box assembly was such that as the crank was rotated it would revolve the cable and worm gear, located and attached to the advancing end of the cable, which would in turn collect the helical springs as it threaded itself through to the opposite end of the sealing closure.

A number of flexible cables were designed and fabricated to eliminate the bulk and stiffness problem, and to provide the remote crank operated gear box assembly with a workable prototype.

In order to fabricate a more desirable and second sealing closure, the molds used for the first closure were modified to include a bar designed to secure the helical springs during the molding process. Also a variation in the elastomers used for the closure were incorporated to provide better adhesion to the helical springs, reinforcement fabric, rubber flow and for additional flexibility.

Upon completion of the new and second closure, it was evaluated and the following results and malfunctions were existent:

a. It was determined that the unit would provide ample sealing capabilities at .5 to 15 psi. However, it was noted that the sealing lips were over turning which caused binding during the remote closing operation.

b. The crank operated gear box assembly did not allow the cable to slide as freely as had been anticipated due to excessive friction and binding which was apparent from within the cable housing channel.

c. The cable was slipping within the gear box assembly due to the use of a round cable.

d. The molds designed to close the ends of the sealing closure were loose, thus allowing rubber to flow into the helical springs which compromised the collecting and threading action of the cable worm gear.

SECTION II

DEVELOPMENT OF FULL PRESSURE SEALING CLOSURE

DURING PERIOD OF MARCH 1963 TO SEPTEMBER 1963

[redacted]

SECTION II: DEVELOPMENT DURING PERIOD OF MARCH 1963 TO SEPTEMBER 1963

NOTE: Section II covers the overall development under the National Aeronautics and Space Administration's contract, number NAS 9-1186.

To complete the Full Pressure Sealing Closure project, the following course of action was undertaken and is currently in progress.

A. ACTION UNDER CONTRACT NUMBER - NAS 9-1186

1. A redesign of sealing closure end molds for elastomer flow control.
2. Develop an improved elastomer that would lend itself to more flow control.
3. Develop a new flexible cable of special configurations with an outer surface coating which would be mechanically adaptable to the crank operated gear mechanism, thus eliminating friction, wear, and binding.
4. Redesign the sealing closure mold to improve the sealing lips.
5. Redesign the crank operated gear box assembly to include ball bearings within the cable housing sector.
6. Purchase a long bed press and extruder.
7. Fabricate a new twelve (12) inch sealing closure.
8. Fabricate a storage casing for the flexible cable.
9. Fabricate a fifty-two (52) inch long mold.
10. Fabricate a full size sealing closure with its accessories.

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B. DEVELOPMENT PROGRESS

1. SEALING CLOSURE

a. March 15, 1963 to May 1, 1963

A detailed chemical and engineering study was undertaken, prototype hardware designed, neoprene compounds developed, molds were machined and the third twelve (12) inch long prototype pressure sealing closure was fabricated. Preliminary evaluation of the sample indicated that the basic design was practical, although the molds used did not provide enough control for the special elastomers developed.

During evaluation it was apparent that the closure would still incorporate a high degree of sealing ability when pressurized from .5 psi to 15 psi (oxygen).

b. May 1, 1963 to June 1, 1963

Redesigns were reduced to drawings and in various stages of fabrication.

c. June 1, 1963 to July 1, 1963

The molding of the end sections to the sealing enclosure was unsatisfactory. This condition existed due to erratic elastomer flow control which resulted in excessive rubber collection (flash) on the connecting surfaces. To eliminate this flash, a reversing of the forward motion in rubber flow was tried by modifying the end mold sections in the following manner:

(1) An opening in the rear of the end mold was installed to provide a path of least resistance to rubber flow.

(2) A gate was installed at the reservoir sector (front) to provide a back pressure condition to rubber flow.

(3) The durometer of the rubber composition was increased to slow down the flow within the mold.

Through the failure of the above efforts, it became necessary to re-submit the end mold sections to the Engineering Department for a new concept in design.

d. July 1, 1963 to August 1, 1963

In order to eliminate erratic elastomer flow which caused excessive rubber collection on the end section connecting surfaces, the end molds were modified incorporating the use of a larger gate. With this modification an end section was fabricated and attached to the main body of a sealing closure. It was found that although the connecting surfaces attached without apparent leakage, appearance was compromised. At this time two additional end sections were fabricated and attached to new sealing closure bodies with added pressure applied in the attaching process. It was found that the appearance was satisfactory, but due to the added pressure, the sealing closure lips became distorted and therefore produced excessive leakage.

e. August 1, 1963 to September 1, 1963

Problems were remedied in the process of attaching the sealing closure end sections to the sealing closure helical spring section. It was found during the fabrication of a new twelve (12) inch prototype, that a reduction of pressure used in the attaching process would, in turn, provide a successful sealing closure both in gas reliability, integrity and appearance.

At this time, the fabrication of a torso area gas container was initiated in which the twelve (12) inch prototype sealing closure would be installed to further evaluate the reliability of the concept.

2. CRANK OPERATED GEAR ASSEMBLY, FLEXIBLE CABLE (SPRING LOCK AND SEAL), AND CABLE STORAGE CASE

a. March 15, 1963 to May 1, 1963

The previously fabricated flexible drive cable and manually operated gear mechanism successfully collected the helical springs, even when engagement was attempted with the closure opened to a 45 degree angle.

Although the closure could be closed and sealed, additional design efforts were required to reduce friction in the drive cable and gear mechanism.

b. May 1, 1963 to June 1, 1963

Further evaluation of the prototype twelve (12) inch long closure previously fabricated, disclosed that excessive friction in the gear mechanism and flexible drive cable compromised smooth operation of the pressure sealing device. Therefore efforts at this time centered on the redesign of these components. Studies concluded that the installation of ball bearings in the crank operated gear mechanism would to a high degree, reduce friction of the assembly. Additional reduction could be attained by changing the drive cable design to provide additional flexibility.
All designs were reduced to drawings and in various stages of fabrication including tooling for the drive cable.

[redacted]

c. June 1, 1963 to July 1, 1963

Two methods to eliminate cable friction in the crank operated gear mechanism were incorporated. The first method used was the installation of two ball bearings (total of 4) 180 degrees apart at each cable housing entry. The utilization of these ball bearings provided an overall bearing coverage of 360 degrees throughout the cable housing sector. As a result, the design and installation technique used caused the cable to buckle in the center of the cable housing sector. A second method was then incorporated, using four ball bearings (total of 8) to provide 360 degree bearing coverage at each cable housing entry. Again, the design and installation techniques incorporated were not sufficient, and as a result, the bearings would not revolve and excessive friction was still apparent.

Due to the failure of these two methods, and the belief that ball bearings were the proper solution, it became necessary to employ engineering assistance from the field of ball bearing industry.

d. July 1, 1963 to August 1, 1963

(1) The David Clark Company, Incorporated, contacted a firm specializing in ball bearing assemblies to assist in incorporating ball bearings into the crank operated gear mechanism. This firm submitted a design concept which was evaluated and approved by David Clark Company engineers. The configuration utilized eight ball bearing assemblies each with an inner and outer race. These ball bearing assemblies were to be located at the opposing corners of the cable, within the cable housing sector; four assemblies at each cable entry. It was anticipated that as the cable rotated on the outer race of the ball bearing assemblies, friction and binding which prevailed in previous experimental models, would be eliminated.

(2) Two flexible cables were given to the David Clark Company engineers on a complimentary basis for the purpose of evaluation. These cables proved unsatisfactory due to their circular design and improper flexibility rate. After additional research it was concluded that a square cable with rounded edges and a flexibility rate designed to complete a circle within three inches of cable length, without distortion in the return position, should be adequate. A die to produce the first actual prototype cable was designed and in the process of fabrication.

e. August 1, 1963 to September 1, 1963

Delivery of ball bearing assemblies which were being fabricated by a vendor facility was delayed due to final design changes. The basic design concept for these ball bearing assemblies, as outlined above were to be utilized.

The final prototype design for the blank gear box assemblies was completed and their fabrication in process.

A blank helical gear was tooled and waiting the delivery of blank gear box assemblies. This helical gear would be attached to the manual drive crank of the gear assembly and act as the "power" or "main" gear for the remainder of the gearing mechanism.

A seventy-two (72) inch flexible cable was designed, fabricated, and waiting to be evaluated with a crank operated gear box assembly. This cable constructed of Monel steel is similar in looks to a speedometer cable. The cable, originally round, is compressed in a die to provide four rounded edges for keying and catching purposes necessary throughout the complete sealing closure assembly. The cable will be coated with Teflon material to eliminate friction and wear which may occur from the helical spring when rotating within the sealing closure. A worm gear is built into the traveling end of the cable which, when rotated, is designed to collect the helical springs and in turn compress the sealing lips of the closure.

To provide cable storage facilities within a full pressure suit assembly, a special case equally as long as the cable itself was designed and fabricated. This storage case is constructed of a rubber coated flexible spring, approximately 1/4 inch in diameter and is designed to be attached to the retreating opening of the crank operated gear assembly, so that as the cable is retrieved from within the sealing closure it will automatically store itself for future suit pressurization.

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SECTION III

DEVELOPMENT OF FULL PRESSURE SEALING CLOSURE

DURING THE MONTH SEPTEMBER 1963

[redacted]

SECTION III: DEVELOPMENT DURING PERIOD OF SEPTEMBER 1, 1963 TO OCTOBER 1, 1963

A. WORK STATUS AND PROGRESS REPORT

1. TEST CONDUCTED ON PROTOTYPE PRESSURE SEALING CLOSURE (see figures I through III)

A prototype torso area gas container has been fabricated with a twelve (12) inch prototype sealing closure installed. This closure extends from the front of the crotch to the lower spinal column area. Using a prototype crank operated gear assembly and flexible cable (spring lock and seal) as the proposed mechanized closing device, the sealing closure was sealed to evaluate its gas integrity and reliability capabilities.

Using a seventy-five (75) pound constant pressure supply source, a pressure regulator and a twenty (20) cubic centimeter flow meter, the gas container was pressurized to a maximum of fifteen (15) pounds per square inch. The following chart indicates the leakage rate in cubic centimeters during each increase of pressure and the time allotted for each test.

MILLIMETER PRESSURE APPLIED PER SQUARE INCH	LEAK RATE IN CC MEASUREMENT	TIME ALLOTED IN MINUTES
20	0	70
60	37	65
80	80	60
100	110	55
130	145	50
140	145	45
160	140	40
180	100	35
200	165	30
220	215	25
240	232	20
260	233	15
280	234	10
300 [redacted]	238	5

<u>NOTE</u>: The leakage rate beyond three hundred (300) millimeters pressure per square inch was not determined at the time of this test.

The closure was opened and closed ten (10) times using the crank operated gear assembly and cable. The above tests were again incorporated and the results did not vary from the original check.

It was evident that the leakage, as indicated in the above chart, was due to a minor distortion of the sealing lips on the sealing closure. This conclusion is based on past experience where a pneumatic distortion leak is high at low pressures and low at high pressures. Examination of the problem revealed that during the molding of the main closure, the tension mandrels, bars which provide alignment of the helical springs during the molding process, were deflected. This deflection resulted in the increased and distorted sealing lip. Also due to the deflection of the tension mandrels, the helical springs were misaligned and caused excessive friction and binding of the flexible cable when collecting or emitting the helical springs.

The proposed remedial course to eliminate these problem areas, is to replace the tension mandrels with new and modified mandrels, and to secure a section of helical springs with a spot weld or some other similar means at each end of the sealing closure before the complete sealing closure body is molded. It is anticipated that incorporating this method with the present fabricating process, along with absolute molding control will provide the desired sealing closure body necessary for a successful full pressure sealing closure assembly.

2. <u>PROBLEMS WHICH MAY IMPEDE PERFORMANCE</u>

At the present time there are no forseeable technical problems concerning the operation or reliability factor in a complete full pressure sealing closure or its accessories.

Although the concept for the full pressure sealing closure has materialized to an ultimately high degree of success in twelve (12) inch prototypes, there has been an unpredictable amount of time involved in their research and development problems. Also necessary prototype fabrication time was alloted to vendor facilities for the construction of components and assemblies which were necessary before project continuance. Due to the unpredictable delays detailed above, an extension has been requested for the successful completion and delivery of Items 1 and 2a, of the contract.

It is anticipated that the financial agreements in the terms of the contract have not been compromised by the development delays, and that they are adequate to successfully complete this project.

[redacted]

3. ANTICIPATED PROGRESS DURING THE NEXT REPORTING PERIOD

a. It is anticipated that the cable's (spring lock and seal) outer surface will be coated with a Teflon material to further reduce friction, binding, or wear.

b. Molds for the fabrication of a full size sealing closure will be in process.

c. The construction of an actual size spacesuit gas container for the installation of a full size sealing closure is scheduled.

d. The prototype crank operated gear assembly will be further evaluated for any existing deficiencies, and finalized for use with an actual spacesuit gas container.

FIGURE I

INFLATED GAS CONTAINER WITH INSTALLED SEALING CLOSURE

AND EVALUATION INSTRUMENTS

1. Millimeter Pressure Gauge
2. Standard Pressure Gauge (psi)
3. Flowmeter (leak rate in cc's)
4. Crank Operated Gear Assembly
5. Flexible Cable Storage Case
6. Cable Entry
7. Torso Gas Container
8. Sealing Closure

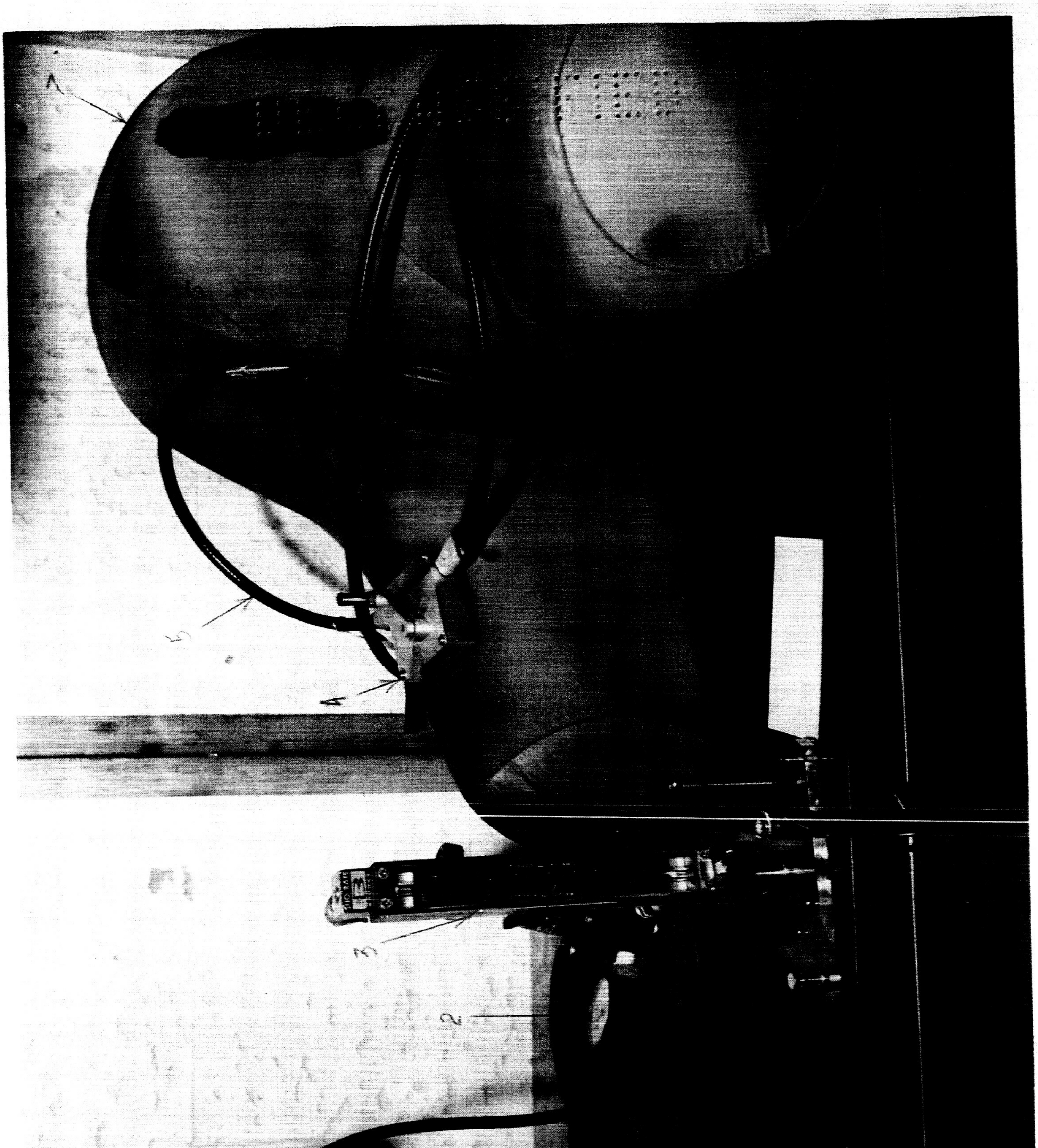

FIGURE 1

Inflated Gas Container With Installed Sealing Closure
And Evaluation Instruments

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October 10, 1963

FIGURE IA

Inflated Gas Container - Rear View

[redacted]

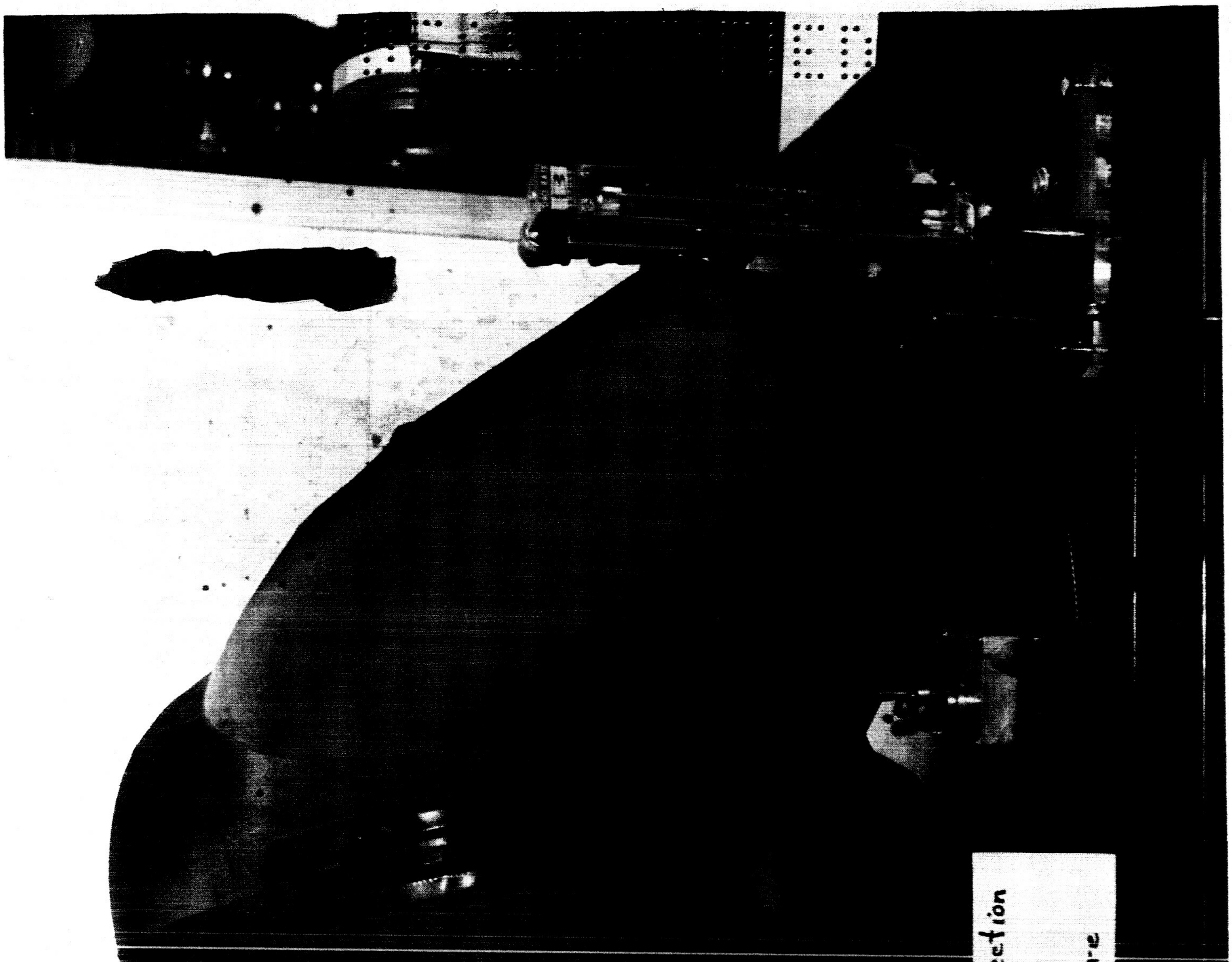


FIGURE 1 A

Rear View

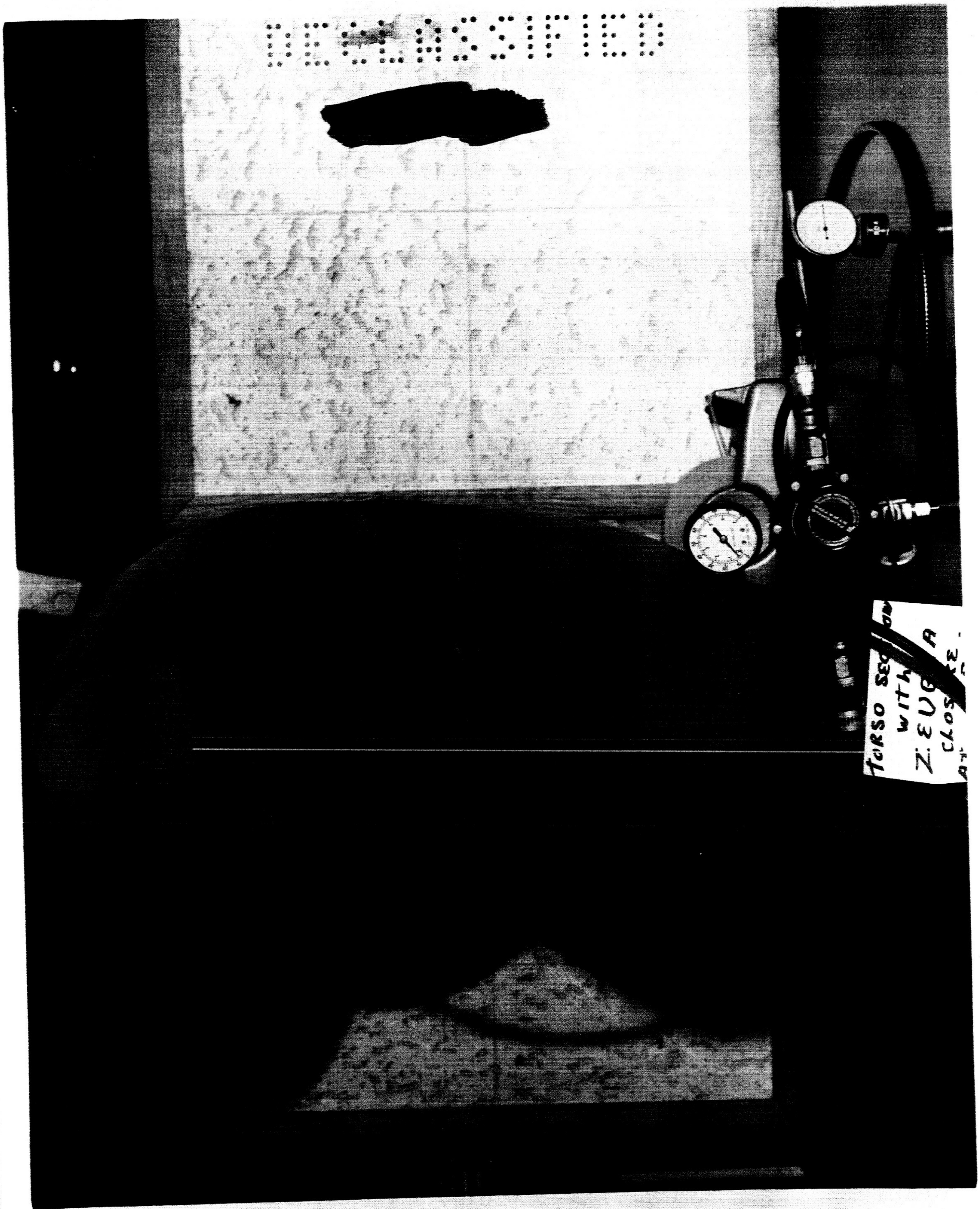
[redacted]

FIGURE IB

Inflated Gas Container - Bottom View

[redacted]

[redacted]



Bottom View

[redacted]

FIGURE IC

Inflated Gas Container - Front View

[redacted]

[redacted]

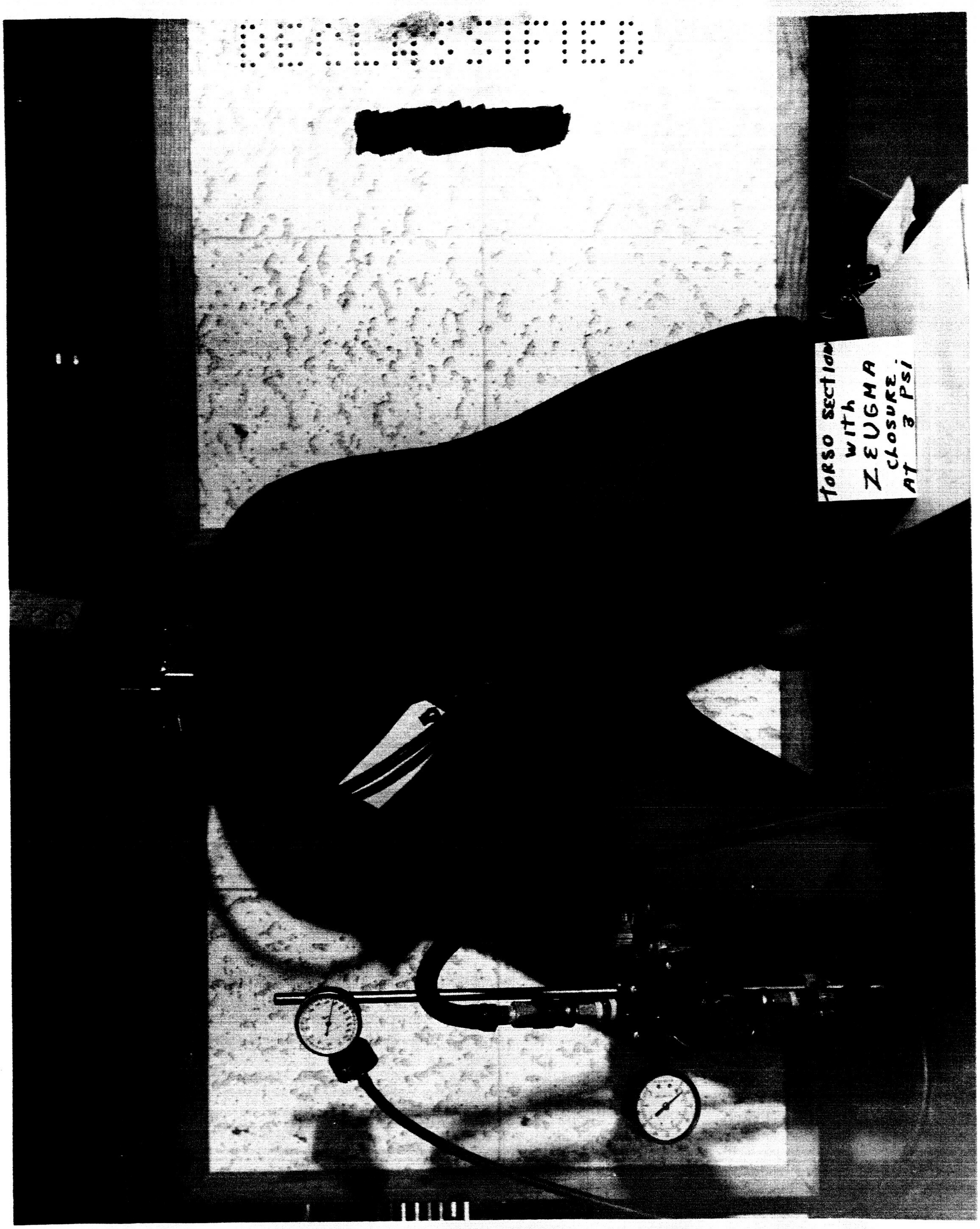


FIGURE 1 6

Front View

[redacted]

FIGURE II

PROTOTYPE SEALING CLOSURE AND CLOSING MECHANISM

1. Twelve Inch Prototype Sealing Closure
2. Worm Gear (helical spring collector and threader)
3. Flexible Cable Storage Case
4. Power Or Main Gear For Crank Operated Gear Assembly
5. Crank Operated Gear Assembly
6. Flexible Cable (spring lock and seal)

Prototype Sealing Closure and Closing Mechanism

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October 10, 1963

FIGURE II A

POWER OR MAIN GEAR FOR CRANK OPERATED GEAR ASSEMBLY

1. Internal Worm Gear
2. Cable Entry
3. Roll Bearing Assembly

[redacted]

Power Or Main Gear For Crank Operated Gear Assembly

[redacted]